Trial Run of the Performance Test Facility for Fuel Assembly Hydraulics and Vibrations Analyses

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1. Introduction

For a development procedure of an LWR fuel assembly, the accomplishment of a performance target must be verified through out-of-pile tests of a fuel assembly and its components.[1] One of the ongoing LWR fuel projects at KAERI is to construct a compatibility test facility to measure and analyze the pressure loss, the lift force, the flow induced vibration and the fretting as well as to verify the compatibility of different fuel assemblies in a transient reactor core.[2] This compatibility test facility of the fuel assemblies is named PLUTO from Performance Test Facility for Fuel Assembly Hydraulics and Vibrations. This paper briefly reports the comprehensive results of thermal hydraulic trial run of PLUTO.

2. Test Facility and Results

In this section some objective and result of the trial runs used to evaluate performance of this facility are described. In this trial run, a flow-housing and fuel assemblies are not installed in the test section.

2.1Test Facility

The PLUTO consists of a primary circulation loop, test sections, instrumentation and controls, data acquisition system, power supply, and auxiliary systems. The primary circulation loop consists of the main circulation pumps, a test section, an expansion tank, a main heat exchanger, and a loop heater as illustrated in Fig. 1. The design pressure and temperature of the PLUTO are 4 MPa and 250 ^{o}C, and the maximum operating conditions are 3.5 MPa and 210 ^{o}C, respectively. The four pumps can deliver up to 1400 m^3/hr water.

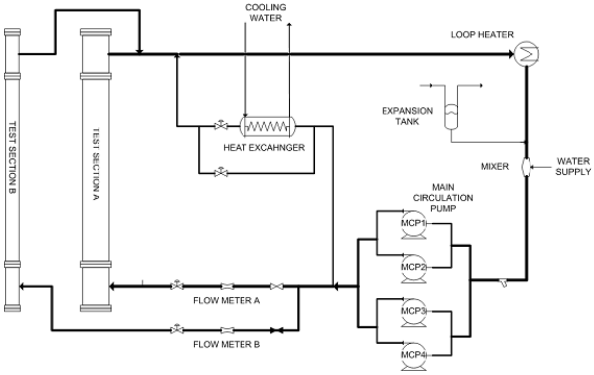

Fig. 1 The schematic diagram of the PLUTO

2.2 MCP Performance Test

The object of this test is to estimate the performance of the MCP(Main Circulation Pump) installed in a facility and the performance test report of the manufacturing company. The test was performed by controlling the flow rate of 400~1400 m^3/hr in the fixed rpm condition of 50 and 55 Hz. This test result is in good agreement with the report of the manufacturing company as shown in Fig. 2.

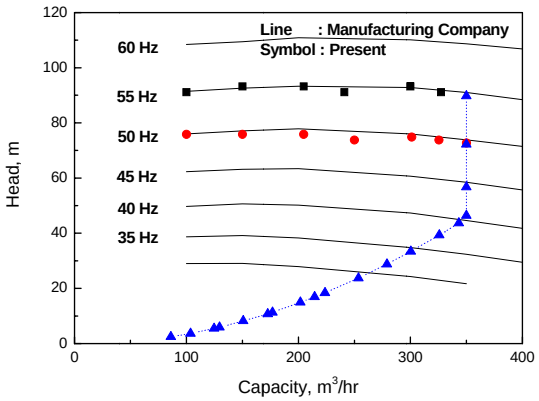

Fig. 2 MCP Performance Test

2.3 Heating Test

To increase the temperature to the test condition, the water temperature is increased by the heat energy from the MCP as well as the loop heater. When the water temperature reaches the target temperature, the heat energy from the heat source should be sufficiently removed by the main heat exchanger. Through out this test, the heat capacity generated from the MCP will be checked. The time required for reaching the target temperature can be inferred. The loop temperature increase is around 18 ^{o}C/hr with only MCP (55Hz, 1650 rpm) and around 25 ^{o}C/hr with the MCP and the loop heater.

2.4 Flow Sweeping Test

The flow sweeping test was performed at a loop temperature of 210 ^{o}C. Axial loop flow was swept from 700 to 1200 m^3/hr. The flow rate took 6 minutes to sweep down (from 1200 to 700 m^3/hr) and then it took 6 minutes to sweep up (from 700 to 1200 m^3/hr). The loop pressure should be maintained at a value to avoid on vaporization. The trends of the outlet pressure and the temperature along with the flow rate are shown in Fig. 3. The temperature and the pressure during the sweeping test was maintained within 1 ^{o}C and within 2.5%, respectively.

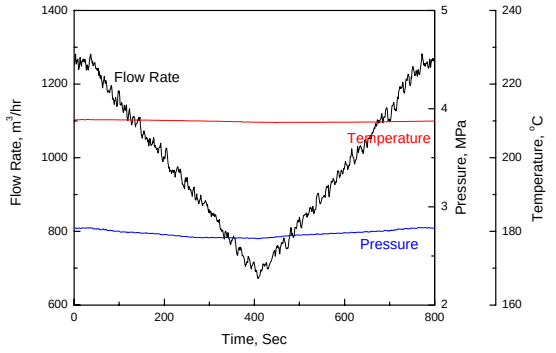

Fig. 3 The Results of a Sweeping test

2.5 Dwelling Test

Beginning at 700 m^3/hr, the flow rate is incremented by 30rpm (average 20 m^3/hr) steps until the flow rate is 1200 m^3/hr. In the real test, the required amount of data at each step will be taken by dwelling at each set point for several minutes in a displacement mode and an acceleration mode. In this test, the temperature was maintained within 1.5 ^oC as shown in Fig. 4. The flow incremental ratio was controlled easily by adjusting the pump rotational frequency.

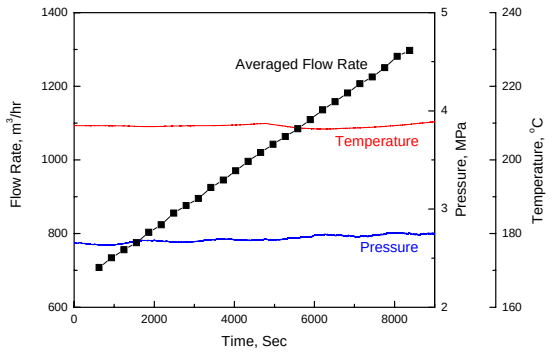

Fig. 4 The Results of a Dwelling Test

2.6 Long Term Operating Test

The duration of the long-term wear test will be 500 hous, but the duration of this trial run was 24 hous. After the desired test temperature (210 ^oC) was achieved, the parametric test, and the sweeping and dwelling test were completed. The loop temperature was controlled by the loop heater, the flow rate was controlled by the pump rpm. The flow rate and the temperature were maintained within 1% and 0.2 %, respectively. The loop pressure was slightly decreased and increased according to the outdoor temperature, however, the pressure was controlled to within 4% by injecting and ejecting a little nitrogen gas into or from the expansion tank. The results are illustrated in Fig. 5.

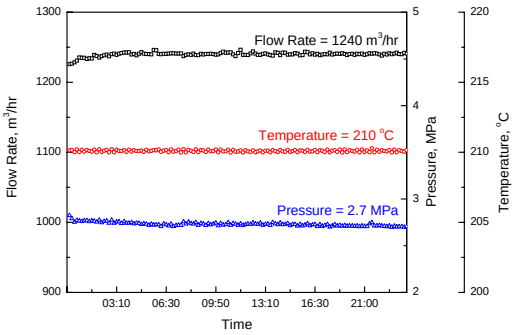

Fig. 5 The Results of a Ling Term Operation Test

3. Conclusions

The trial run of PLUTO (Performance Test Facility for Fuel Assembly Hydraulics and Vibrations) was performed. Through the pump performance test, the total performance of the pumps installed in the loop is in good agreement with the individual test report of the manufacturing company. The loop temperature increase is around 18 ^oC/hr with only MCP (55Hz, 1650 rpm) and around 25 ^oC/hr with the MCP and the loop heater. PLUTO will be reach the maximum operation temperature in around 10 hours. During the parametric test of the sweeping and the dwelling mode, the loop condition could be maintained stably. The maintenance of the steady state at the test condition was confirmed for 24 hours. The PLUTO has an excellent performance for the Hydraulic test of Fuel Assemblies. The vibration test performance will be estimated in the next stage.

ACKNOWLEDGEMENT

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